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Status of Mabee's Salamander, *Ambystoma mabeei*, in Virginia: A Spatial Comparison of Habitat Condition at Sites of Known Occurrence

J. Ryan Niccoli and John D. Kleopfer

Department of Game and Inland Fisheries
3801 John Tyler Memorial Highway
Charles City, Virginia 23030

ABSTRACT

Negative impacts of human settlements and population expansion on pool-breeding amphibians are well known. This, coupled with an increasing rate of urbanization across the globe, instigates the need for constant reassessment of habitat critical to the survival of these animals. In Virginia, the pool-breeding Mabee's Salamander (*Ambystoma mabeei*) is confined to the southeastern corner of the state. Knowledge about the populations and habitat quality within this range is limited. The goals of this project were to 1) visit known sites for *A. mabeei* in Virginia and reassess the habitat condition and species' occurrence and 2) assess changes in land use (1992-2001) in proximity to known sites for *A. mabeei* in Virginia and extrapolate the future of the species' occurrence at these sites. Visual Encounter Surveys were performed and land use data were analyzed within multiple buffer zones surrounding known sites. Over 80 ha of suitable habitat within 300 m of known sites for this species in Virginia were lost due primarily to human activity and land development.

Key words: *Ambystoma*, development, habitat, occurrence, range, spatial, urbanization.

INTRODUCTION

Globally, one of the major challenges faced by amphibians today is urbanization (Hamer & McDonnell, 2008; Tsuji et al., 2011). Amphibians tend to be especially sensitive to habitat effects such as habitat loss, fragmentation and isolation, and degradation, as well as alien diseases that result from urbanization (Alford & Richards, 1999; Houlahan et al., 2000; Mitchell, 2004; Gibbs et al., 2005; Cushman, 2006; Hamer & McDonnell, 2008; Baldwin & deMaynadier, 2009; Tsuji et al., 2011). Because more than 50% of the global human population resides in urban areas, and this population is growing constantly, this threat source is an ever-increasing cause for alarm in the conservation community (Tsuji et al., 2011). Other human stressors, such as intensive forest management that causes degradation to terrestrial amphibian microhabitat, as well as canopy removal, which alters ground level environmental conditions, can have large negative impacts on these amphibians (Freidenfelds et al., 2011).

In the United States, pool-breeding amphibians such as the mole salamander family, Ambystomatidae, and Wood Frogs (*Lithobates sylvaticus*) tend to be at high risk for multiple reasons (Hamer & McDonnell, 2008; Baldwin & deMaynadier, 2009; Freidenfelds et al., 2011; Tsuji et al., 2011). Compounding urbanization's negative impacts, pool-breeding amphibians in the U.S. also suffer from inadequate habitat protection in and around their breeding pools (Baldwin & deMaynadier, 2009; Freidenfelds et al., 2011). These breeding pools are often underrepresented in the U.S. Fish and Wildlife Service's National Wetland Inventory maps (Baldwin & deMaynadier, 2009). Silvicultural practices add another stressor for these amphibians (Freidenfelds et al., 2011). Outside of the breeding season, many pool-breeding amphibians emigrate from the pools into surrounding upland areas, making it critical habitat for conservation efforts (Mitchell, 2004; Baldwin & deMaynadier, 2009; Freidenfelds et al., 2011). Because the rate of urbanization is so high, frequent assessment of land use changes in areas bordering habitat known to support pool-breeding amphibians is imperative to the conservation of these species (Baldwin & deMaynadier, 2009).

One such animal belongs to the North American family Ambystomatidae. Mabee's Salamander

Fig. 1. Mabee's Salamander (*Ambystoma mabeei*) from the Grafton Ponds Natural Area Preserve, York Co., Virginia. Photo by S. M. Roble.

(*Ambystoma mabeei*; Fig. 1) inhabits Virginia along with five other ambystomatids, including *A. tigrinum* (Eastern Tiger Salamander), *A. jeffersonianum* (Jefferson's Salamander), *A. opacum* (Marbled Salamander), *A. talpoideum* (Mole Salamander), and *A. maculatum* (Spotted Salamander) (Mitchell & Reay, 1999). *Ambystoma mabeei* is a small ambystomatid, with adults reaching a total length of about 8 to 12 cm (Mitchell, 2005).

Adult *A. mabeei* inhabit forested areas, usually close to a suitable breeding site. Breeding sites consist of fish-free, ephemeral ponds in pine savannas, bogs, sinkholes, low wet woods, swamps, sandy pinewoods, or cypress-tupelo stands, as well as semi-permanent farm ponds, flooded foxholes, Carolina bays, and occasionally ponds in open, grassy fields (Hardy, 1969; Pague & Mitchell, 1991; Petranka, 1998; McCoy & Savitzky, 2004; Mitchell, 2005).

Both juveniles and adults of *A. mabeei* move considerable distances from the breeding pools after breeding and metamorphosis. Newly metamorphosed juveniles have been captured up to 800 m from their natal pond. Juveniles and adults remain fossorial outside of the breeding season. Information about underground activity in *A. mabeei* is lacking, but other *Ambystoma* species are reliant on underground tunnels. (Pague & Mitchell, 1991; Mitchell, 2004, 2005; Gamble et al., 2006)

According to the Virginia Fish and Wildlife Information System (VAFWIS), *A. mabeei* reaches the northernmost extent of its range in Mathews County, Virginia (Fig. 2). It also occurs in Gloucester, Isle of Wight, Southampton, Surry, and York counties and the cities of Hampton, Newport News, and Suffolk (Mitchell & Reay, 1999; Mitchell, 2005). The overall range of the species is restricted to the Coastal Plain regions of the Carolinas and Virginia (Pague & Mitchell, 1991; Petranka, 1998; McCoy & Savitzky, 2004).

The International Union for Conservation of Nature (IUCN) lists all Virginia species of *Ambystoma* except *A. mabeei* as having stable global populations. Although *A. mabeei* is noted as being in decline by IUCN, it is listed as a species of Least Concern (IUCN, 2009). Nature Serve ranks the salamander as G4, as it is "apparently secure" in its global range (Mitchell, 2005). The Virginia Department of Game and Inland Fisheries (VDGIF) lists *A. mabeei* as a State Threatened Tier II species of greatest conservation need in Virginia (Buhlmann et al., 2003).

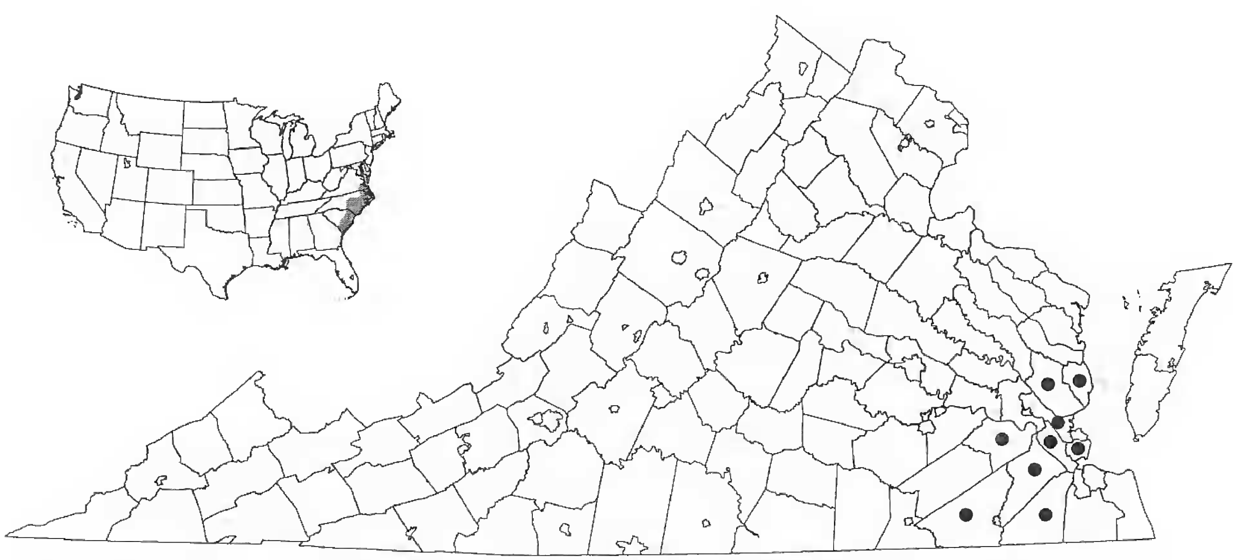

Fig. 2. Distribution of *Ambystoma mabeei* in Virginia and eastern United States (modified from Mitchell & Reay, 1999).

Due to increased human development in southeastern Virginia in recent decades, it is necessary to reassess the population status and habitat utilized by *A. mabeei* in the state. The goals of this project were to 1) visit known sites for *A. mabeei* and, when possible, reassess the habitat condition and species' presence at each and 2) assess changes in land use from 1992 to 2001 in proximity to known sites for *A. mabeei* in Virginia and 3) to extrapolate the future of the species' status at these sites.

METHODS

Initial assessments were made for all known localities of *A. mabeei* in Virginia using Google Earth satellite images. Visual Encounter Surveys (VES) were conducted at selected sites deemed not to have been destroyed upon the review of satellite images. Many sites were located on private property, and some sites were not visited due to lack of landowner permission during this early assessment period. Surveys were conducted from late January to February 2010 and in January 2011, between one and four times per site during the two-year period, when adults should be active (Mitchell, 2005). More extensive and repeated surveys, as well as surveys for larvae during the spring season, were not performed due to time constraints. Methods involved flipping logs near and surrounding ponds, gently combing through leaf litter, and limited searching in ponds for eggs.

In addition to field survey assessments, Arc Geographic Information Systems (ArcGIS) computer software program was used to assess changes in land use in proximity to known *A. mabeei* sites between 1992 and 2001. This period was chosen due to constraints of available National Land Coverage Dataset (NLCD) layers, which were obtained from the U.S. Department of Agriculture's Natural Resource Data website (MRLC, 2009). Known locations for *A. mabeei* were mapped from Global Positioning Systems (GPS) coordinates and separated into seven geographic units based on county location and geographic proximity to other sites. Buffers of 30 m, 50 m, 100 m, 200 m, and 300 m were established around known sites in order to examine changes in land use categories surrounding them.

A minimum buffer of 30 m was used because it is the required buffer size for mitigation and land protection surrounding wetland systems in Massachusetts, which is one of the strictest states for wetland protection (Gamble et al., 2006). In Virginia, no such mandatory upland protection exists. The maximum recommended buffer for Mabee's Salamander in Virginia is 250 to 300 m (VDGIF, 2010). The maximum buffer of 300 m is based on the Recovery Plan (Buhlmann et al., 2003). The three remaining interval buffers between 30 m and 300 m were chosen to allow for additional comparisons. Other studies of *Ambystoma* species have shown that animals emigrate between 30 and 1230 m from their breeding pools (Semlitsch, 1998; Facio, 2003; Gamble et al., 2006; Montieth & Patton, 2006). All buffers were created with dissolved boundaries in order to maintain an accurate representation of the area calculated for each unit, especially where proximal records caused overlapping buffer zones. Land use summary statistics were compiled and compared for all buffer regions in all subsets. Comparisons of land use categories were based on habitat types and our determination of habitat suitable for both terrestrial and breeding/larval aquatic stages for this species.

The definition of Suitable Habitat types derived from the NLCD files for the purpose of this paper is any forested or wetland areas. These consist of the following land use categories for both 1992 and 2001: Hardwood Forest, Pine Forest, Mixed Hardwood-Pine Forest, Forested Wetlands, and Emergent Wetlands. These land use types are considered to contain both suitable and marginal habitats. Marginal habitats are included in the Suitable Habitat category due to the possibility that these animals may experience limited dispersal abilities in some areas and be confined to using marginal habitat. The land use category of Open Water includes many waters which had a sustained fish presence at all times of year, and therefore was classified as unsuitable for use in the Suitable Habitat definitions. All land use types that did not fall into the category of Suitable Habitat (e.g., Open Space Developed, Barren Land, and Cultivated Crop) were treated as Unsuitable Habitat (Pague & Mitchell, 1991; Petranka, 1998; McCoy & Savitzky, 2004; Mitchell, 2005).

RESULTS AND DISCUSSION

Results from the assessments of land use within buffer zones surrounding known *A. mabeei* sites for each geographic unit are shown in Figures 3 through 9. The figures show Suitable Habitat change across the study period (1992-2001) for each of the five multiple ring buffers, with a total Suitable Habitat Change category also included. Suitable Habitat Change was calculated by subtracting the 2001 values of Suitable Habitat from the 1992 values, therefore a negative bar on a graph indicates a gain in Suitable Habitat.

Surry County

The area surrounding the one site record for the Surry Unit changed relatively little between 1992 and 2001 (Fig. 3). Major changes close to the GPS coordinates for the record show a shift from Forested Wetland to Hardwood Forest land use types, which could represent a loss of breeding habitat for these salamanders. Over the entire 300 m buffer zone, the site actually gained a total of 0.1 ha of Suitable Habitat from 1992 to 2001.

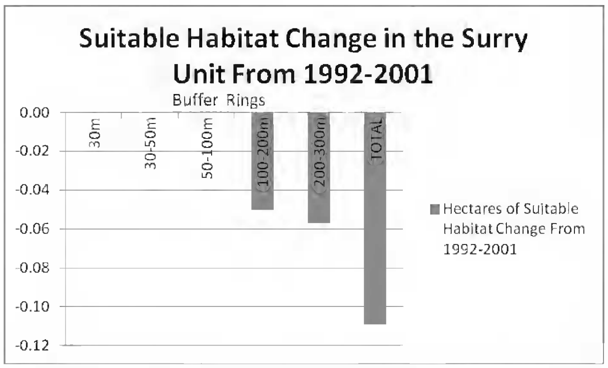

Fig. 3. A summary of statistics compiled for the single record of *Ambystoma mabeei* occurrence in the Surry Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net gain of 0.11 ha of Suitable habitat.

City of Hampton

While modest gains of Suitable Habitat were made within the 30 and 50 m buffer zones in the City of Hampton Unit, the total area lost more than 1.3 ha (Fig. 4). The greatest losses were made just beyond the 50 m buffer zone, with the 100 and 200 m buffer areas accounting for more than 1 ha of Suitable Habitat lost.

City of Suffolk

The three records in the City of Suffolk Unit display gains in Suitable Habitat in all buffer zones, totaling in excess of 7.7 ha (Fig. 5). This represents the highest proportion of Suitable Habitat gained among all subsets at more than a quarter of the total land area within the buffer zones being reclaimed.

Southampton County

No Suitable Habitat gains were made in the Southampton County Unit, which accounts for four records (Fig. 6). A total of 3.4 ha of Suitable Habitat was lost in this unit. Major habitat loss occurred within 200 meters of the records, accounting for 3.2 ha of the total Suitable Habitat lost.

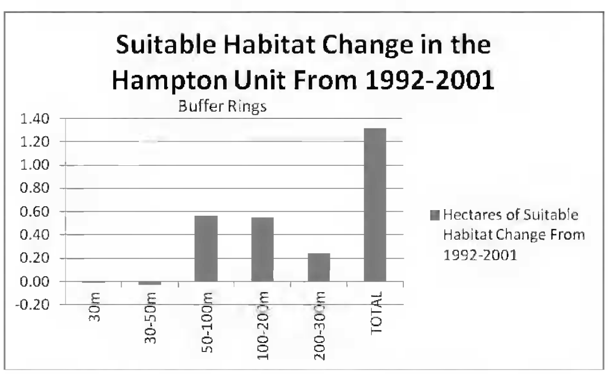

Fig. 4. A summary of statistics compiled for the two records of *Ambystoma mabeei* occurrence in the Hampton Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 1.31 ha of Suitable habitat.

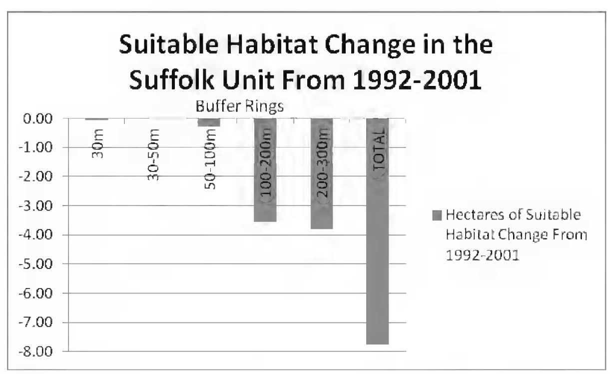

Fig. 5. A summary of statistics compiled for the three records of *Ambystoma mabeei* occurrence in the Suffolk Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net gain of 7.75 ha of Suitable habitat.

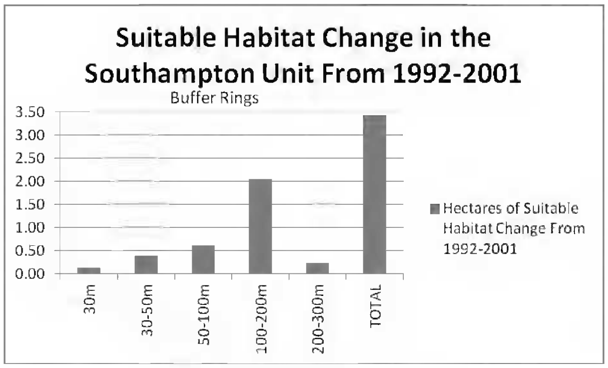

Fig. 6. A summary of statistics compiled for the four records of *Ambystoma mabeei* occurrence in the Southampton Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 3.43 ha of Suitable habitat.

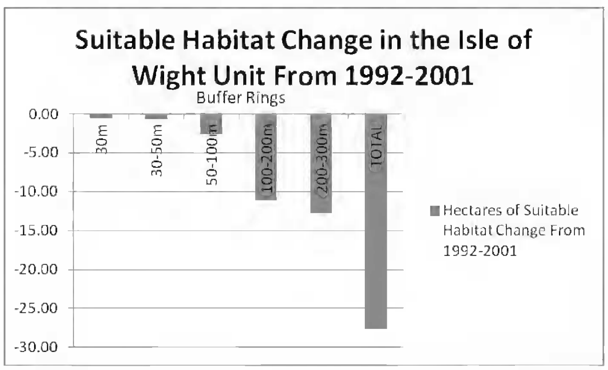

Fig. 7. A summary of statistics compiled for the seven records of *Ambystoma mabeei* occurrence in the Isle of Wight Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net gain of 27.69 ha of Suitable habitat.

Isle of Wight County

The Isle of Wight County Unit, which contains seven records, displayed the highest total area of Suitable Habitat gained among all subsets (Fig. 7). More than 27.6 ha were gained in Suitable Habitat, representing a reclaiming of 23.2% of the total land area within the buffer areas surrounding these sites.

Gloucester and Mathews counties

The nine records located in the counties of Gloucester and Mathews Unit exhibit no gains in Suitable Habitat for any buffer areas. Gains of Pine Forest and Forested Wetland categories were offset by losses in Hardwood Forest, Mixed Hardwood-Pine Forest, and Emergent Wetlands categories. The total loss of Suitable Habitat in these two counties was 12.8 ha, with most losses between the 50 and 300 m buffer zones (Fig. 8).

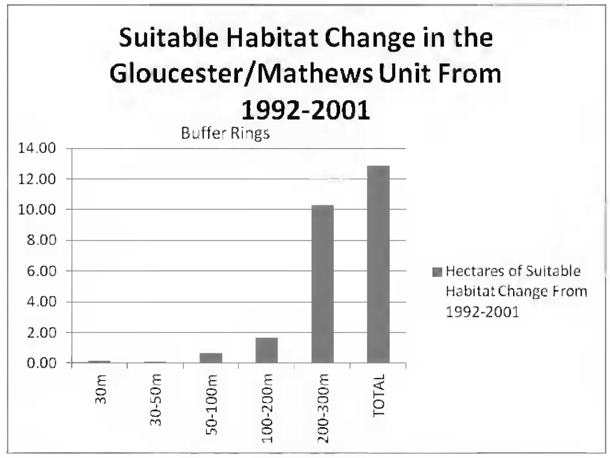

Fig. 8. A summary of statistics compiled for the nine records of *Ambystoma mabeei* occurrence in the Gloucester/Mathews Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 12.88 ha of Suitable habitat.

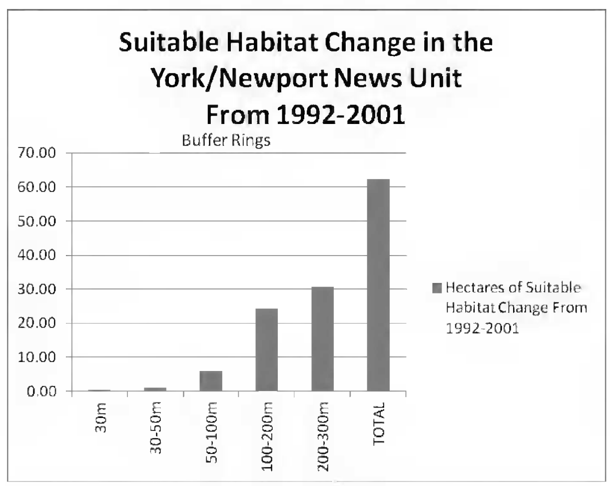

Fig. 9. A summary of statistics compiled for the sixty-four records of *Ambystoma mabeei* occurrence in the York/Newport News Unit. Calculations were performed for each buffer zone, starting with the 0-30m zone and ending in the 200-300m zone. A net Total category was also established for an overall view. Change of Suitable habitat between 1992 and 2001 is shown here, amounting to a net loss of 62.31ha of Suitable habitat.

York County and City of Newport News

The largest unit of records (n=64) exists in the York County and the City of Newport News Unit. Most of these occur in an area known as the Grafton Ponds Natural Area Preserve, and represent the largest known population of *A. mabeei* in Virginia. Of the 64 records, and more than 707.6 total ha, 62.3 ha were lost from Suitable Habitat categories between 1992 and 2001 (Fig. 9). Even though it represents less than 9% of the considered land area, this is still an enormous loss of potential habitat for this salamander in Virginia, especially considering that it was lost from an area that holds one of the most robust populations in the state. The land was lost in large part to increases in human development such as Low, Medium, and High Intensity Development, as well as to the Cultivated Crop and Barren Land (Rock/Clay/Sand) land use categories.

The information contained in Figures 3 through 9 is summarized in Table 1 on the basis of the Suitable Habitat parameters. In the overall study area, approximately 46.8 ha shifted from Suitable Habitat to Unsuitable Habitat between 1992 and 2001, but this figure is slightly misleading. In reality, more than 80 ha of Suitable Habitat were lost to multiple land use categories collectively in Virginia. This represents a significant loss for a species whose population may already be stressed in Virginia. On the other hand, approximately 35 ha of suitable habitat for *A. mabeei* were gained during the same time period. The Isle of Wight County Unit represents the highest percentage increase at more than 27 ha of suitable habitat reclaimed at seven sites. While this gain was not made as a result of any active habitat management program targeting *A. mabeei*, it nevertheless provides a potentially valuable source of habitat for this species.

Table 1. A summary of statistics compiled for the change in suitable habitat for *Ambystoma mabeei* across Virginia. Calculations were performed for each year over a total assessment of all buffer zones and all research Units. There has been considerable loss of suitable habitat surrounding known sites for *A. mabeei* during the 9-year period, amounting to a total of about 46 ha.

All of Virginia	1992	2001	Habitat Change, 1992 to 2001
Habitat quality	Hectares		
Suitable	971	925	-46
Unsuitable	261	307	+46
Total Hectares	1232	1232	

Due to the limited person-hours during this survey, no *A. mabeei* were encountered, thus no data regarding current presence/absence at the selected known sites was obtained. Survey sites were visited a maximum of four times across the two years. Additional VES may confirm presence of the species at some sites, but a lack of observations should not be viewed as proof that the species no longer occurs at these sites.

Human activity at some sites was confirmed during VES through both proximity to residences and presence of trash. Human activity around sites has also been confirmed by the comparison of development category land use values around the known sites from 1992 to 2001. Due to the secretive nature of *A. mabeei*, it is difficult to delineate population boundaries and where any migration corridors occur without the use of technologies such as radiotelemetry. Although we have documented a significant loss (46.8 ha overall) of potentially suitable habitat for this species, what remains to be studied is the effect that human activity has on fragmenting smaller populations, and how this translates into genetic isolation.

It is expected that some changes in forest type or other land use types will occur over time due to vegetative succession. Throughout the study area, Hardwood Forest held the highest acreage value of all land use categories within buffer zones for both years, but is considerably lower in total acreage in 2001 compared to 1992. Pine Forest experienced a sharp increase from 1992 to 2001, presumably due to silvicultural practices. Given the scope of this project, per-site analyses were not performed. This is important to note because known populations of *A. mabeei* in Virginia are sparsely distributed, and the destruction of key breeding sites may result in loss of populations. This may in turn negatively impact their ability to disperse, again causing a possible decline in genetic variability among individual populations.

Suggestions for further research on *Ambystoma mabeei* populations in southeastern Virginia include revisiting this study on a per-site analysis basis. Following the completion of our analyses, the U.S. Department of Agriculture finalized delineation of a new NLCD representing the year 2006, as well as an NLCD 1992/2001 Retrofit Land Cover Change product. Analysis of these two Land Cover Data sets would provide a more accurate and current land use assessment and provide another data point to evaluate ongoing land use trends. Further VES would assist in providing confirmation of the presence or absence of remaining populations at known sites, which would allow for a more accurate overall assessment of the future presence of *A. mabeei* in Virginia.

As is true in much of the United States, no mandatory protection of upland habitat areas surrounding ephemeral wetlands exists in Virginia, a fact that needs to be addressed because a significant portion of the life cycle of *A. mabeei* and other pond-breeding amphibians depends upon extensive use of wooded upland systems (Semlitsch, 1998; Facio, 2003; Jenkins et al., 2006). Capture-recapture and radiotelemetry studies would also assist in assessing density and home range of *A. mabeei* populations in Virginia, and may prove crucial to future legislation pertaining to wetland/upland protection. Biologically delineated salamander life zones, which represent critical wildlife habitat, should be considered a viable means to estimate the area of upland protection that should be applied, and should be utilized in forest management practices (Semlitsch, 1998; Facio, 2003; Montieth & Patton, 2006).

On a broader scale, loss of ephemeral wetlands is a major concern for numerous species, and for local, state, and federal organizations in the U.S. (Van Meter et al., 2008). Geographic Information Systems should be incorporated into new studies, including multiple land cover data sets to develop a model for predicting and delineating ephemeral wetlands across the landscape. The effects of human proximity and anthropogenic activities to these wetland systems are little known, but could have a high impact because these ponds are often fed by groundwater and runoff (Carrino-Kyker & Swanson, 2007). This relationship should be examined in more detail to determine the effect it is having on salamander populations within breeding pools. Habitat fragmentation is also a significant threat to pond-breeding amphibians and needs to be addressed in future studies utilizing GIS (Semlitsch, 1998; Rothermel & Semlitsch, 2002; Skidds et al., 2007).

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